THE ADAPTIVE EFFECTS OF COGNITIVE MOTOR TRAINING

GLI EFFETTI ADATTIVI DEL COGNITIVE MOTOR TRAINING

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ABSTRACT

This study explores the effects of Cognitive Motor Training (CMT) in improving cognitive and motor skills, with a focus on neurodevelopmental disorders. CMT integrates motor and cognitive exercises, promoting a synergy between brain functions that favors functional adaptation and self-regulation. The results show significant improvements in educational inclusion and quality of life.

Questo studio esplora gli effetti del Cognitive Motor Training (CMT) nel miglioramento delle capacità cognitive e motorie, con un focus sui disturbi neuroevolutivi. Il CMT integra esercizi motori e cognitivi, promuovendo una sinergia tra funzioni cerebrali che favorisce l'adattamento funzionale e l'autoregolazione. I risultati mostrano significativi miglioramenti nell'inclusione educativa e nella qualità della vita.

KEYWORDS
Cognitive Motor Training, Executive Functions, Neuroplasticity
Cognitive Motor Training, Funzioni esecutive, Neuroplasticità

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Introduction

The conceptual and theoretical body of neuropedagogy and, more generally, of behavioral sciences, hosts and develops the paradigm of Cognitive Motor Training - CMT which, through the entire theoretical and practical system, studies, operates and reflects in favor of rapid and intentional effective actions. The paradigm is expressed through the plurality of scientific and professional actions whose clinical significance extends to the prevention, evaluation and enabling treatment of growth disorders and human functioning, fundamental to *knowing to include* (Giaconi & Capelllini, 2015). CMT is articulated through a theoretical framework and educational and intensive professional practices, aimed at the rapid and efficient activation of intentional actions in *functional training cycles,* which can fluctuate in frequency, which varies from 2 to 4 days of activation, with a continuous intensity that engages the professional and the subject for 4 to 6 consecutive hours a day. The aim is to functionalize the subject to make efficient the neuronal flows of the cortical circuits, the interhemispheric exchange, the prompt activation of the incipit *, the* executive fluidity, the self-regulation processes: the cognitive executive functions are made fluid through neurological activation. CMT is outlined through the theoretical framework and the *setting* , which expresses the scientific and professional context and specifies the action that takes place there. Its conceptual place must be understood through the theory that accompanies it, the professional practices and the emerging research for *inclusive action* (Aiello & Giaconi, 2024).

CMT is transversal and its disciplinary scope refers to multiple behavioral sciences and professions, although connections with intentional and scientifically committed professional interventions to the sense of care and well-being are privileged, even in the healthcare sector. Cognitive Motor Training is a topic on which a growing international attention converges and recent research and professional applications that have also involved Italy explore a series of reasonings, such as:

- cognitive control and sport;
- decision-making processes;
- influence of a dedicated cognitive-motor protocol;
- cortical connectivity;
- executive functions and attention;
- neuroactivation ;

- neurophysiological and neurocognitive mechanisms;
- interactive modes of operation and physiology and effects;
- neuromuscular strength;
- *unicum*: it is one of the few treatments in which the study of the different methods of applying CMT has produced positive results throughout life.

Cognitive Motor Training is a functionalizing cognitive action and is widely accepted in the therapies of people with disorders and disabilities, obtaining important training gains in a relevant series of aspects, such as socialization and *enjoyment,* therefore its benefits pervade the processes of building happiness, the self and inclusion. The brain action that underlies it is the result of a series of activations of rigid regulations. This pushes the higher brain functioning to overcome the rigidity that characterizes it and through the neuromotor pathway, through the intensive activation of the subject's thoughts, further levels of functional coordination are reached. The intensity of the training *and* the cyclicity of its occurrence is constitutive of CMT because it works for the energy efficiency of the subject, since it asks the subject's brain system to find energy with continuous and stable action power to distribute it simultaneously in the brain system based on the task to be performed. The functional practices of CMT implement effective actions for the overall strengthening of the individual and his adaptive processes. In this paper, the nature of CMT is analyzed in relation to forms of developmental diversity or functional disorder, plurally related to spatial-temporal and praxis disorders that affect an increasingly larger group of children.

More pertinent references are to the vast phenomenon of *functioning,* therefore of *dysfunctional behaviors,* on which neurophysiology and the sciences that refer to it focus their attention. Dysfunction, in fact, tends to manifest itself in various forms and at different levels of intensity, mainly exposed in the functional areas of perception, language and communication, attention, memory and, overall , neurodevelopment.

This significantly shifts the meaning of the intervention, since it operates at an educational level on mental processes and not on the products of the mind, placing this enabling modality in the cognitivist approach through an operational strategy, aimed at enhancing the formation of learning subjects characterized by a reduced freedom of adaptation, since they think later, they activate later. These subjects suffer in welcoming and responding to environmental requests.

Man always experiences, exercising his functionality, activating the quality of experience capitalized from a mnemonic point of view. It communicates with the

space-time relationship, with laterality, with the automation of motor and cognitive circuits and therefore with the elicitation of cognitive electrical potentials and other neurophysiological aspects, such as blood flow.
Space and time impact the real natural and cultural context, generating the need to produce motor and cognitive behaviors. When all this happens with difficulty then we need a professional who works in a context that favors the production of functional and organized motor and cognitive actions: the goal is to allow the subject to proceed to the formulation of plural and personal degrees of functional regulation.
Each subject is typical as such, his behavior typifies the person for a functional diversity, which means that subject activates the quality of his actions, carrying them out in a disordered way, we could say *dyspraxic* : it means carrying out actions in an altered way in space and time with respect to efficiency and effectiveness, but also to fluidity and accuracy. We find the space-time disorder in perception, in language, especially in the aspects related to the kinetic dimension. The transversality of *dyspraxia* is also found in the insufficient motor coordination and in the reduction of sequential memory, therefore the subject who currently has to be very synthetic in telling a story and finds it difficult to line up a prolonged series of information. Dyspraxic functional behavior is therefore characterized first of all by an activation of automatisms, including psychomotor automatisms that support conscious actions, intentional actions precisely because there is a temporal alteration and therefore this involves the malfunctioning of a fundamental element which is the dispersion of cerebral energy: subjects who experience this condition of disorder exhaust their energy and therefore get more tired. These subjects enter into what is defined as *cognitive confusion* (Crispiani et al., 2019) because they are no longer able to retain information, or to process that which is clearly conveyed by the environment in which the subject finds himself.
Today we are witnessing a change in everyone's lifestyle. There are new operations that redesign the space-time relationship, determining a different interactive articulation between the functional and the real. Professionals are called to generate plural forms of interaction with the environment and therefore to better favor the construction of functional behaviors and their application to life contexts. The changes that occur in reality influence the reiteration of functional and even dysfunctional behaviors, because the organization of the individual's personality develops through a dynamic synergy of psychic, motor and psychomotor functions, which, feeding each other, create the implementation of a very ordered behavior.
The space-time of thought implies the possibility of having a thought that moves in time and space and when it is ordered and coordinated it is anticipated by the

subject who interacts in an *authoritative* or self-determined way. The child, especially in the phases in which he begins to initiate motor patterns, structures a time and a space that are operationalized in the plurality of cognitive processes. This synergy favors the structuring of functional behavior.

Instead of a genetic or epigenetic Neurodevelopmental Disorder, we witness an alteration of this synergy and therefore the birth of dysfunctional behaviors.

Slowness in disorders has become a shared criterion in the scientific and professional community and there are many cases of slow subjects who do not demonstrate an efficient system of use of the motor areas, with a consequent increase in disorders.

Furthermore, considering the plurality of disorders that affect the quality of thought in relation to the reduction of cognitive potential, it becomes fundamental to focus operational action on the strengthening of these processes that today are critical at all ages.

Before doing anything, the subject must be able to accelerate cognitive coordination, so it must be able to immediately activate attention, immediately recognize information, allow the recovery of previous information and know how to process it.

Those who are in difficulty therefore have partially adequate functional capacities because cognitive coordination is slowed down and not supported by adequate stimulation of the motor areas, producing a slowness in the phases of starting and stopping actions. These subjects therefore do not have a *starting point* , hence the importance of *neuroactivation* which is one of the key principles of the Crispiani Method (Crispiani, 2015), therefore they have difficulty self-regulating, they slow down little or move towards a language that is awkward or absent: the general slowing down prevents thought from producing ideas because it alters the speed between the idea thought and the idea produced. There is also a difficulty linked above all to the application of sequential automatisms, a difficulty in interpreting and ordering a large and complex problem. These are some of the characteristics also linked to the fact that the possibility of keeping a series of information in memory is reduced: in the presence of disorder there is always a reduction in sequential memory. Thought therefore tends to apply itself rapidly and rigidly and rarely becomes proactive, that is, it is able to hypothesize, imagine, or rather it is a thought that remains very blocked in space-time, it does not move or change its mind, it is immobile.

CMT proposes intervention methods that are characterized by being a form of cognitive strategy, an ecological strategy that involves the entire human functioning, which implies the stimulation, education and enabling of all human

functions, according to a *praxic-motor approach* that in this case is representative of motor and cognitive activation.
With Cognitive Motor Training we want to work on human functioning by activating all these processes so that practices and therefore organized behaviors can be built. Therefore, to strengthen the practice it is essential to address some objectives, strengthen *synesthesia* , that is, being able to simultaneously coordinate the application of multiple functions, especially perceptual-motor and perceptual-linguistic, extend mnestic processing also through memory and cognitive-motor segmentation, therefore maintaining information in memory, promoting a rapid understanding of the context with integration of information, accustoming the subject to temporally placing information, therefore developing this temporal order and finally making the subject economically efficient from an energy point of view. The subject must be able to sustain a mental effort to keep up with the environmental cognitive load.
This paper aims to explore CMT as an enabling modality, reflecting how individuals, in the process of functionalization through CMT, make the most of their behavioral efficiency and effectiveness.

1. Neuroscience and CMT

Functional enablement is a complex action of the mind that subjects undertake with a certain degree of partiality because they struggle to generate a global behavior: functional integration is the goal, which involves a certain degree of criticality and difficulty and scientists deal with it in a transdisciplinary framework. This contribution intends to reflect on a representative sample of scientific and neuroscientific devices, using the accounts of scholars who have developed diachronic and synchronic explorations of the possible functional dimensions of CMT, whose expansion finds a horizon of meaning in the scientific representation of the construct of functionality. Taking action involves anticipation, a phase to take the intended action, a phase to carry out the action, a phase to conclude the action, and a subsequent phase to gain certainty and control or *feedback*. Performing actions at any level implies mastery of one's functional system, knowledge of the action and its praxis or textual form. We can therefore outline an ecological system of action for which the formation of cognition contextualizes a considerable series of factors whose combination produces effects greater than the actions themselves. Given the relationship between an individual's cognitive abilities and numerous factors such as educational and occupational achievement (Deary et al., 2007), socioeconomic status and stress levels (Evans & Schamberg, 2009), and

happiness (Koval et al., 2013), the idea that cognitive performance can be improved is extremely appealing.

Pioneering studies on CMT can be traced back to authors such as:

- Richard A. Schmidt, who makes fundamental contributions to the field of motor learning;
- Timoty D. Lee, who specified his interest because he has conducted studies on cognitive-motor training;
- Gabriel Wulf, who contributes to the implementation of implicit training theory and its effects on motor learning.

There are then a series of studies that explore the effects of CMT in pediatric age.

Santner et al. (2018) seek to understand whether training influences brain development, although it is still unclear what type of exercise can induce higher cognitive effects and whether concomitant mental engagement provides additional efficacy. The study aims to understand the motor and cognitive effects in subjects aged 6–10 years, resulting from a 9-week habilitation action. Trainings include the automation of coordination exercises with concomitant mental tasks and multi-sport exercises with and without mental tasks. Benefits have been found in combining automated coordination exercises with mental tasks.

There is further research conducted by a group of scientists from Basel interested in the effects of CMT, who focus their interest on the relationship between brain functions and anticipation (Lucia et al, 2021).

Walsh (2014) questions whether sport is the greatest challenge for the brain. He believes that the application of cognitive neuroscience to sport science leads to innovative exercises such as cognitive-motor training. Further clarification comes from the research of Hotting et al. (2013), who believe that exercise has beneficial effects on executive functioning and memory in people: neural systems change through exercise, as they allow the maintenance of cardiovascular fitness essential for any long-term benefit on cognition. This form of cerebrovascular activity generated by CMT allows the human brain to change according to needs, altering its functional and structural properties: neuroplasticity is activated *which* results in learning and skill acquisition.

benefits are hypothesized for neurogenesis, synaptogenesis, angiogenesis which are all essential for the release of neurotrophins necessary for the neural mechanisms that mediate the cognitive effects of physical exercise. So in summary:

- neurocognitive benefits are obtained if motor and cognitive activities are combined simultaneously;
- we can maintain the neurocognitive benefits induced by physical exercise if we also work on our cardiovascular fitness level.

A group of scientists study psychomotor efficiency from the perspective of the optimal, that is, they observe expert athletes who possess refined attention strategies and an efficient motor program (Chuen et al. 2023). To understand their performance, they interrogated the brain, using an electroencephalogram, exploring frontal theta power, left temporal alpha power, sensorimotor rhythm and frontocentral alpha power and power. The investigation aims to understand the positive relationship between these neural processes and the likelihood of effective cognitive-motor performance. The results revealed that concomitant increases in frontal theta and left temporal alpha were contextual to adequate performance, as well as concomitant and coordinated activation of motor processes implicated by sensorimotor rhythm and central alpha suggest a greater likelihood of success. This contribution highlights that a dedicated distribution of attention and adequate processing of the motor program are fundamental cognitive aspects of superior cognitive-motor performance for experts.

Moreau et al. (2015) work on a new approach to cognitive training based on complex motor activities. Through the randomized controlled design of the study, participants were assigned to only one of three conditions:

- aerobic exercise;
- working memory training,
- sport designed to include both physical and cognitive demands.

The groups did not train for 8 weeks, there were many benefits especially in the designed sport group that achieved significant global cognitive gains, highlighting how complex motor activities are essential to improve cognition and reduce heart rate and blood pressure. Again, if we examine the effectiveness of complex motor activities to improve cognition, through the complex coordination of designed sport, then we can find improvements in working memory capacity and spatial ability.

Then there are the CMT investigations developed with technology. The investigation moves on to the relationship between cognition, sport and mental rotation. They are Pietsch et al. (2017), who study precisely how long-term physical activity in specific sporting activities can change the quality of mental rotation performance. Through the study of *Life Kinetik* , a movement program with cognition and motor coordination tasks effective on the mental rotation performance of 44 school-age children, showing a significant increase in mental rotation capacity.

Hayakawa and Kobayashi in Japan conducted several studies and initially explored the effects of training young people with intellectual disabilities with the aim of improving their motor skills (Hayakawa and Kobayashi, 2011). Subsequently,

Hayakawa and Kobayashi (2013) studied the effects of CMT on intellectual disability in subjects aged 12 to 21 years, who underwent a training program to improve motor skills, endurance, muscle strength and motor balance using fifteen types of training machines. The results were measured mainly using observation of the participants' movements, fitness tests, questionnaires and video monitoring. Their training improved their health and above all produced effects on social skills, such as the ability to self-control their behavior and the acceptance of rules resulting from the instructions of others, generating cooperative interaction. The technology was developed by Dr. Kobayashi and the word cognitive was used for training because cognitive skills related to the control of body movements are a fundamental requirement for proper machine exercise, especially sprint machines and *elliptical orbit power bikes , where the* ipsilateral foot, knee, hip and shoulder must move in the same direction in a forward motion, to achieve effective use of the core muscles of the torso. Nervous control, different from typical motor behaviors, is used in the *ipsilateral movement* of the lower and upper extremities of the body and is initially difficult for most individuals, but becomes easier as focused attention is implemented.

Studies show that individuals with intellectual disabilities have a limited capacity for muscular effort when it is necessary to concentrate force in a prescribed manner.

Casella et al. They conducted confirmatory studies of the benefits obtained on executive functions for aspects of the cognitive system of human functioning through the application of CMT on adults and elderly. Through psychokinetic CMT, the positive outcomes of the treatment on executive functions are confirmed, observable through those behaviors that express the planning and visual search abilities of young soccer players. The researchers conclude that CMT is effective for improving planning and visual search abilities, even in children (Casella et al., 2022).

Kasatkin et al. (2024) conducted a prospective pilot study to evaluate the feasibility and effects of cognitive-motor intervention on cognitive and motor skills of cognitively impaired children aged 7 to 18 years who were survivors of posterior fossa tumors and who had completed specific primary treatment. The researchers generated work sessions and training included:

- general motor training - GMT;
- graphomotor training – GT;
- cognitive-motor training - CMT.

visuospatial working memory, visual attention, hand-eye coordination, semantic verbal fluency, auditory-motor synchronization, reaction time, and a decrease in the rate of ataxia, which warrant further research.

In Italy, CMT boasts the professional figure of the Cognitive Motor Trainer and its professional training is based on the Cognitive and Motor Theory of Piero Crispiani's group of scholars. The Crispiani method has among its lines of action: neuro-activation (which constitutes the platform), basic instrumental enhancement (reading, writing, mathematical skills, motor skills and language) and disciplinary or cultural enhancement. It presents itself as a strategy accompanied by a technological system that articulates professionals and professional actions, as well as procedures and materials, cognitive teaching strategies and environmental design for the plurality of educational moments. CMT is characterized by a series of activities that guide processes elicited with intensity for greater neurophysiological activation and the dynamization of action sequences in constancy and fluidity. Through the execution of a conscious and automatic activity of motor, perceptive, graphomotor, mnemonic, linguistic and thought sequences, the enhancement of the function and the organ is generated. The simultaneous, coordinated and constant activation of the functions is a reason for reorganizing the cortical flows and enhancing their effectiveness. The CMT is developed and coordinated by the Video Motor Training Itard, by the Champion LIRM work method for intensive reading and *Speed Motor* and by the book Champion Pressing (Palmieri, 2023) Training that intensifies the CMT.

Scientific studies demonstrate a close correlation between language, motor skills and cognition, verifying that the different developments proceed in parallel, influencing each other.

These systems reach their full form during adolescence and in this

visual-motor skills are optimized general and bimanual coordination, together with the development of cognitive abstraction skills, metacognition and social skills. Researchers report a slow rate of electrical activity evident as early as six months, which may predict difficulties in developing words and language between the ages of three and five. These difficulties may predict problems in the development of brain circuits that process the rapid transitions involved in perceiving the basic units of spoken language. If a child cannot hear or process quickly enough as an infant, some elements of language may be hindered in fluency. Increased reading efficiency is now recognized as the key to fluent reading. In this approach, based on over 10 years of observations, rehabilitation treatments and targeted experimental interventions with children with severe deficits, we demonstrate the effectiveness of a motor and fluency treatment. Through intensive practice based on cross-pattern activation aimed at improving general executive functions and procedural/sequential motor skills, we find that reading and writing improve in terms of fluency. A clinical study, conducted before and after the Champion LIRM

intervention, on a sample of 20 dyslexic children between 7 and 13 years of age showed an average improvement of 50/60% in activation times, accompanied by an improvement in reading. After the intervention, both measures accelerated towards the performance of control children, who provided normative data for the study, although dyslexic children remained significantly slower. Working in intensive cycles of 2 or 3 days, for a total of 15 hours, using a constant rhythm, applying sequences and motor coordinates, we promote the underlying processes of rapid activation, improving the automation of neural circuits and exchanges between hemispheres. This improvement and functional gains also extend to attention, general reactivity, balance and language (Crispiani, 2017).

2. Between the cognitive and the engine for functional innovation: the functional principles of CMT

Today, neurobiological and pedagogical convergences allow us to develop knowledge of Executive Functions-EF and their contributions to the activation of useful forms of early intervention and treatment or enabling interventions for subjects living in *inclusive educational ecosystems* (Giaconi et al., 2023). The paradigm of Executive Functions, which can be defined as disordered and non-fluent execution of intentional actions in relation to the environment, from a selective point of view, concerns a neurophysiological condition for the optimization of global human action, such as general coordination, activation of the incipit, self-regulation, spatial-temporal organization, lateral dominance and other functions that pertain to functional processuality.

The approach and the long professional experience in the specialized pedagogical field recover theoretical concepts and intuitions expressed since the twentieth century, to arrive at today's neurophysiology that pays particular attention to the phenomenon of neurological disorder/disorganization, concerning dyspraxia, or motor coordination, language, ideation, emotion, graphic-motor ability, which materializes in: space-time disorders, executive disorders and developmental disorders. The scientific and experiential contribution belongs to a theoretical model that is defined as *Cognitive Motor Training* and develops an intense and ecological practice by recording and documenting sensitive instrumental developments, in the sense of fluidity and accuracy and a general improvement in cognitive participation and motor speed. In particular, functional gains are directly related to reading, writing and mathematics performance and to adaptation in general.

When we reflect on cognitive-motor training for performance and cognitive functions in athletes, it is essential to consider the brain processes associated with the components of the *event-related potential* - ERP with respect to the task. It is a motor system that performs self-determined anticipatory warnings. A wave is generated that carries an event-related electrical potential that is able to anticipate the start, start to proceed, proceed to close and finally close the action with positive feedback. Only if the feedback is positive is there learning and implementation, otherwise with negative feedback the elicited potential is not suitable for adaptive performance as it produces weak responses. This is why behavior involves cognitive discrimination of responses. Instead of dysfunctional actions, it becomes essential to modify the cognitive-motor course through specific training programs.

CMT that works on the *neuromatrix* is organized on a motor training protocol that, working on complex deafferentations, offers opportunities for reorganization of global functioning. The synergic activation of motor and cognitive activity involves the execution of tasks that, through intense exercises, modify neurological organization, coordination, laterality and blood and cardiovascular flow. Cognitive Motor Training - CMT develops activation and acceleration practices neurophysiological in cases where the executive functions that occur are disorganized in the slowness, clumsiness and incoordination of the action (Crispiani, Palmieri, 2023).

Executive functions are found in the prefrontal lobes and are defined as executive processes conception, activation, control and coordination of intentional and purposeful human action, therefore of the functioning of the cognitive system which are expressed in the regulation of human functions (motor, perceptive, emotional, motivational, communicative, intellectual, linguistic, relational, operational), and the related synesthesia, making it possible to exercise intentionality, problem solving, quality of action, etc., in general, adaptation (Crispiani, Palmieri, 2023).

The practice of CMT is aimed at activating motor and cognitive activities and gestures voluntary (motor, communicative, perceptive, emotional, etc.) in order to activate, exercise and to strengthen precisely those executive functions involved in the practices of ideation, planning, execution, control and automation and is aimed at activating intentional functional processes (motor, perceptive, emotional, thought, relational and communicative) in a regime of readiness and executive coherence, which constitute the basic conditions for superior scholastic or conceptual learning, in any case necessary for the person's life, along a path of strengthening and subsequent stabilization (Crispiani, Palmieri, 2023).

The use of Champion Pressing determines the acceleration of the incipit, the strengthening of spatial organization, the acceleration of action planning and proactive thinking, the reduction of inertia and conditions of evasion from the task, the strengthening of the processes of self-regulation, self-instruction and self-inhibition and the improvement of reading, writing and mathematical skills.

This practice, if performed with the right intensity - GI and the right pressure - GP, causes an Accelerative Behavioral Change – SAC, which allows to reach biopsychic reactivity defined as *Functional Awakening* , a state that counteracts developmental disharmony.

Qualitative research conducted shows that responses improve. They exert a particular functional advantage on the homeostatic regulation of anticipatory cognitive processes and proactive inhibition as the brain tends to adapt cognitive functions through the intensive activation of *neuroplasticity processes* .

The CMT provides:

1. distribute attention;
2. perform automatic actions;
3. actions in *dual-task, multi-task, synesthesia mode* ;
4. combination of physical and cognitive exercises;
5. coordinate your breathing.

Crispiani and Palmieri's CMT is based on the natural *simultaneity* of motor and cognitive activity, not on succession, and constitutes a *dual-task training* , aimed at *executive functions* rather than a distinct sequential training between motor and cognitive (Moreira et al., 2021).

In athletes, the goal of CMT is to:

- Increase performance by focusing on specific transferable skills
- improve general cognitive abilities (Taatgen, 2013).

Cognitive functions include: perception, attention, concentration, reasoning, creative thinking, memory, decision making (Taatgen, 2013).

There are complementary proactive cognitive functions, such as inhibition, anticipation (Aron, 2011) essential in sports and mainly in *open-skill ones* in which the scenarios that require the preparation of the best action change rapidly, for example basketball. The cognitive and neuro-functional aspects of control that occurs between *feedforward* and *feedback, the* attentional and then inhibitory push and the new anticipation of the action combine seamlessly.

The ability to anticipate upcoming events and proactively control future actions requires a combination of:

- sensory input
- search strategies

- pattern recognition
- awareness of probabilities.

This can be achieved in electroencephalographic examinations on rapid and complex dynamics by observing the amplitude of the waves visible in the examinations of Event-Related Potentials with millicentennial precision of the motor phases that pass from preparation to the end of motor execution (Di Russo, 2017). "Recent literature has shown that sports practice can influence the anticipatory frontal components of the ERP, which are involved in the execution of complex sensorimotor cognitive tasks" (Berchicci et al., 2020).

Discrimination of DRT responses requires a strong involvement of anticipatory cognitive functions, which appear to involve occipital and frontal activities (Di Russo, 2019) pre-stimulus anticipatory components or *Bereitchaft Potential* – BP and Prefrontal Negativity – NP or proactive inhibition to action "starting approximately one second before the onset of the stimulus", allowing the *vigilant and self-regulated interactive motor modality.*

The larger the pre-stimulus anticipatory capacity (BP), the faster the RT for response selection, while the PN or prefrontal negativity or proactive inhibition, predicts the accuracy of the response, so the larger the PN, the lower the error rate. The activation potential (Bereitschaft Potential - BP) (Shibasaki and Hallet, 2006), anticipatory potential – premotor potential, readiness potential, anticipatory readiness potential, propagates in the motor cortex and supplementary motor area of the brain and reflects the excitability of the supplementary motor arteries and the belt, and precedes every voluntary act.

The PN originates from the inferior frontal gyrus (Di Russo, 2016) has been associated with proactive cognitive functions such as top-down attention and inhibition in the prefrontal cortex (Di Russo, 2016) and self-control of actions (Di Russo, 2019). There are then a series of investigations on elderly people conducted by Berchicci (2020) on prefrontal hyperactivity and temporal cueing in relation to time in the task of preparing the brain for action (Berchicci et al., 2020). All these components regulate a cognitive system of acceleration/brake, or activation/inhibition, which predicts and anticipates future actions (Di Russo, 2016). In Response Discrimination-DRT, you have to respond quickly and accurately and refrain and inhibit inappropriate responses, so this means making both cognitive and motor demands. Let's think about two different types of CMT:

CM + DT training via interactive devices.

CM-DT training protocol for basketball using interactive devices, designed to create activities that stimulate specific cognitive functions and simultaneously physically train athletes with one of the fundamentals of basketball: dribbling.

You are required to do your homework in advance.
If CM-DT reduces RT in DRT, the arterial pressure amplitude should increase.
If CM-DT improves accuracy rates, this should be reflected in an increase in PN width.
Cognitive-motor training – CMT
CM-DT training involves the simultaneous execution of physical and cognitive exercises that involve strong inhibitory control (of other stimuli) "in order to deactivate any oppressive or distracting reaction during task execution and attention" (Crispiani, Palmieri, 2023). Here CMT is intended as a "dual task", motor + cognitive, to see the effects on anticipatory brain activity. The BP and PN components index the preparatory motor and cognitive activities that precede stimulus presentation, respectively. Training improved both speed and accuracy.

Conclusions

Overall, the present study demonstrated that the proposed CMT cognitive-motor training protocol is highly effective in improving sports performance. This improvement was considered from a practical perspective of physicians, psychologists or coaches who wish to include cognitive training in addition to technical-motor training in their team's training program. At the neural level, we demonstrated that anticipatory prefrontal activity could be a preferential target of cognitive-motor training. Furthermore, we propose that PN is not only associated with anticipatory attention and inhibition, but is also called upon to achieve specific athletic goals, presumably through neuroplasticity processes.
We hope for further studies that analyze the benefits of CMT and that investigate the possible introduction of CMT into the life plan.

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